Spatial distribution of Bluetongue surveillance and cases in Switzerland

G. Kluiters[1], V. Chaignat[2], H. Schwermer[3]

[1]Royal Veterinary College, London, UK, [2]Institute for Virology and Immunoprophylaxis (IVI), Mittelhäusern, Switzerland, [3]Federal Veterinary Office (BVET), Berne, Switzerland

Summary

Swiss Bluetongue surveillance from mid 2007 to mid 2008 was a combination of monthly bulk milk testing of 200 cattle herds in zones of higher risk for vector presence and intensification of passive clinical surveillance. The spatial scan statistic and Moran's I statistic were used to determine clustering of surveillance data. The results show a high level of surveillance intensity for BT in Switzerland in 2007. In the region encompassing the Cantons of Aargau, Basel-Landschaft, Basel-Stadt and Solothurn, where cases were detected in 2007, the surveillance was significantly higher than in the rest of Switzerland. Six cases of Bluetongue were detected within the surveillance system. The prevalence estimates 9.62% (95% CI = 3.25%–18.85% versus 0.98% (95% CI = 0.2%–2.22%) were also significantly higher in the area with higher surveillance intensity. Spatial variation in surveillance data should to be considered if a disease event is analysed on a national scale. The spatial variation of prevalence estimates should be considered in future Bluetongue surveillance in Switzerland.

Keywords: Bluetongue, bulk milk serology, cluster analysis, surveillance, cattle

Räumliche Verteilung der Überwachung und der Fälle von Blauzungenkrankheit in der Schweiz

Von Mitte 2007 bis Mitte 2008 bestand die Überwachung der Blauzungenkrankheit in der Schweiz aus einer kombinierten monatlichen Untersuchung von Sammelmilchproben von 200 Rinderherden und einer verstärkten klinischen Überwachung. Die Rinderbetriebe wurden gezielt in Gebieten mit hoher Wahrscheinlichkeit für das Vorkommen der Vektoren ausgewählt. Mittels «Spatial Scan Statistic» und «Moran's I Statistic» wurden die Überwachungsdaten auf räumliche Häufungen (Cluster) untersucht. Die Ergebnisse zeigen eine hohe Überwachungsintensität in der Schweiz in 2007. In einer Region, welche die Kantone Aargau, Basel-Landschaft, Basel-Stadt und Solothurn und damit das Gebiet, in dem 2007 Fälle von Blauzungenkrankheit nachgewiesen wurden, umfasst, war die Überwachungsintensität signifikant höher als im Rest der Schweiz. Im Rahmen des Überwachungsprogramms wurden 6 Fälle entdeckt. Die Schätzwerte für die Prävalenz waren mit 9.62% (95% CI = 3.25%–18.85%) innerhalb des Gebietes mit höherer Überwachungsintensität versus 0.98% (95% CI = 0.2%–2.22%) ausserhalb signifikant höher. Die räumlichen Unterschiede in der Überwachungsintensität sollten daher berücksichtigt werden, wenn Seuchenausbrüche auf nationaler Ebene untersucht werden. Daher sollte auch die räumliche Verteilung der Prävalenzschätzwerte in der Schweiz in der zukünftigen Überwachung der Blauzungenkrankheit berücksichtigt werden.

Schlüsselwörter: Blauzungenkrankheit, Tankmilchserologie, Clusteranalyse, Überwachungsprogramm, Rinder

Introduction

Bluetongue (BT), a vector-borne viral disease of ruminants which, until recently, was restricted to tropical and subtropical areas of the world has now spread to geographical areas where it was not previously found (Mellor et al., 2008). Bluetongue Virus (BTV), of which 24 serotypes are known, is a member of the genus *Orbivirus* (family Reoviridae) (Mertens et al., 2008) and BTV is transmitted by midges of the genus *Culicoides* (Mellor et al., 2000). Until recently *C.imicola* was believed to be the only important vector of BTV in Southern Europe,

544 Originalarbeiten

but it is now known that several species, newly recognised as vectors, are also involved (Mellor et al., 2008). These species are abundant and widespread in Switzerland but a period without vector activity has been demonstrated from December 2007 to April 2008 (Schwermer et al., 2008). BTV is transmitted between its ruminant hosts almost exclusively through the bite of adult females of the vector species and global distribution of the disease is therefore restricted to regions where these vectors occur, and transmission to the season of vector activity (Mellor et al., 2000). In sheep BTV causes an acute disease with high morbidity and mortality, with symptoms including swelling of the face and tongue and rarely, cyanosis of the tongue (OIE, 2008a). Cattle and goats usually exhibit subclinical infections, and therefore serve as important viral reservoirs (MacLachlan, 1994). Serotype 8 (BTV-8) however, which is currently endemic in northern Europe, is associated with distinct clinical signs and mortality in some cattle (Backx, 2008). Naturally infected animals produce antibodies that are detectable for life. In experimentally infected animals, PCR positive results are observed up to 200 days post infection in ruminants (Bonneau et al., 2002).

Since 1998, BTV has been causing outbreaks in Europe involving serotypes 1, 2, 4, 8, 9 and 16, with the largest epidemic of BTV-8 in 2006 affecting the Benelux, France and Germany, which, as of September to November 2007, spread to the Denmark, Switzerland, Spain, the United Kingdom and the Czech Republic respectively (OIE, 2008b; Hofmann et al., 2008). In Switzerland, due to the presence of BT serotypes in southern Europe, a nation-wide serological survey was conducted in 2003 (Cagienard et al., 2004), as well as the establishment of entomological trapping at sites (Racloz et al., 2007). This survey confirmed the absence of BT (Cagienard et al., 2006) and led to the creation of an early warning system with sentinel herds (Racloz et al., 2006). Following the northern European outbreak in 2006 a more extensive surveillance programme was called upon, which consequently started in June 2007. One requirement for the whole system was to fulfil the specification given in the EU regulation (EC) No 1266/2007 (Anonymous, 2007a). The Federal Veterinary Office (FVO) decided on bulk milk testing and passive clinical surveillance.

The bulk milk testing strategy was based on the regular monthly sampling of 208 cattle herds distributed throughout the country in zones of higher risk for vector presence. It was initiated in July 2007 and lasted until June 2008. Switzerland was divided into 16 BT-regions (Tab. and Fig. 1) in accordance with EC 1266/2007 (Anonymous, 2007a). In each BT-region at least 11 farms had to be sampled monthly. The farms were chosen randomly

Table 1: Number of animals and farms participating in each surveillance method and the total number per BT-region as well, as results of serological surveillance and clinical suspect reports. neg: negative, fp: false positive, tp: true positive, pop: total population on surveillance farms

BT-Region	km²	Cattle/ Sheep Population[1]	Cattle/ Sheep Farms[1]	Bulk milk Testing[2]		Sheep Surveillance[3]	Clinical Suspects Tested[2]		
				Farms neg/tp	neg/fp/tp	Farms	Farms neg/tp	Cattle pop/neg/tp	Sheep pop/neg
AG	1,404	90,674 / 16,286	2,489 / 550	11/-	106/-/-	3	7/-	276/7/-	-
AI/AR/SG	2,441	175,877 / 46,499	5,533 / 1,405	14/-	125/1/-	3	5/-	264/7/-	-
BE Middle	2,010	176,350 / 27,898	6,957 / 1,530	13/-	120/-/-	1	8/-	229/5/-	63/3
BE North	1,328	71,119 / 8,082	2,217 / 417	12/-	101/-/-	2	9/-	666/10/-	13/1
BE South	2,621	60,938 / 10,502	2,545 / 384	15/-	97/2/-	-	5/-	75/2/-	147/4
BS/BL/SO	1,345	72,958 / 14,499	2,002 / 504	14/1	113/1/1(+1)4	6	31/3	1257/149/9	310/21
FL	160	5,826 / 5	124 / 70	2/-	18/-/-	-	2/-	132/2/-	-
FR	1,671	130,046 / 12,817	2,978 / 478	12/-	86/-/-	1	7/-	209/7/-	-
GE/VD	3,494	119,671 / 15,344	2,800 / 316	13/-	82/-/-	-	7/-	304/3/-	169/9
GR	7,105	74, 757 / 61,828	2,270 / 1,223	14/-	67/3(+2)4/-	1	7/-	258/18/-	96/2
JU/NE	1,641	87,183 / 6,755	1,744 / 218	9/1	56/-/1	1	3/-	369/3/-	-
LU	1,493	141,265 / 15,157	4,905 / 876	14/-	127/2/-	2	3/-	112/3/-	-
TG	991	73,585 / 15,482	2,195 / 394	13/-	123/-/-	2	8/-	204/6/-	215/1
TI	2,812	10,750 / 16,707	454 / 253	12/-	121/1/-	-	-	-	-
UK/GL/ZG	3,675	120,586 / 40,948	4,417 / 1,221	13/-	122/-/-	5	7/-	212/6/-	27/1
VS	5,224	27,130 / 62,629	1,484 / 1,027	12/1	82/1/1	-	2/-	11/1/-	118/1
ZH/SH	2,038	108,423 / 20,236	2,982 / 520	14/-	129/-/-	1	8/-	322/9/-	-
Total:	41,453	1,547,138 / 391,669	48,096 / 11,386	208/3	1,675/11(+2)/3(+1)	28	119/3	4900/238/9	1,158/43

[1]Number of animals according to Federal Office of Agriculture (2006)
[2]Number of animals/ farms determined by number of samples received
[3]Number of farms according to FVO database
[4]Number in brackets indicates number of repeat tests undertaken
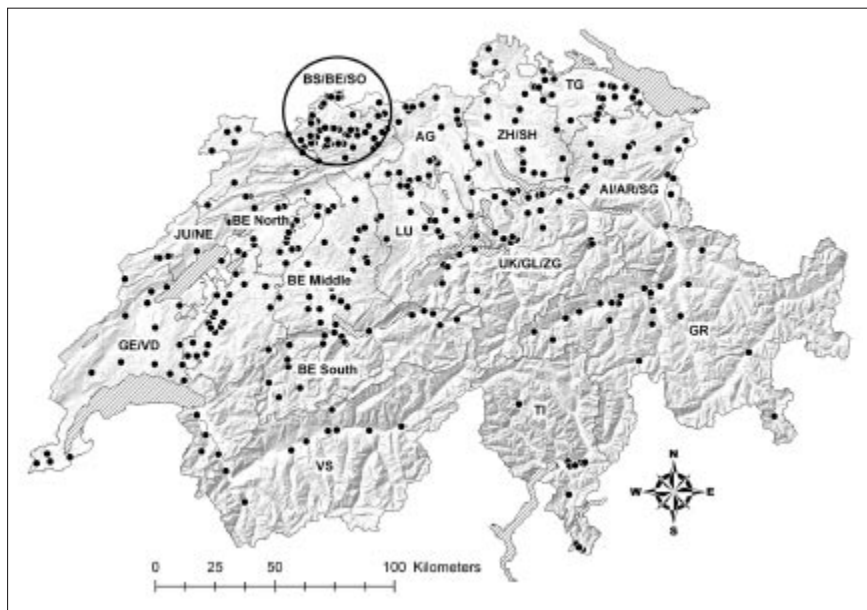[5]Total number of sheep in Lichtenstein unknown

Figure 1: The BT-regions and all surveillance farms with most likely cluster (cluster A) obtained when all surveillance methods are combined.

but had to be verified by the Cantonal Veterinary Service (CVS). The Principality of Liechtenstein formed as an additional region with two farms sampled (Schwermer et al., 2008). Nationwide passive clinical surveillance was also intensified, whereby farmers were asked to be vigilant for clinical symptoms and report them promptly to their veterinarian (Schwermer et al., 2008). The FVO and the CVS have thus launched an information campaign in August 2007 for farmers and veterinarians based on a freely distributed BT documentary movie, information leaflets, information on the internet in its own domain (http://www.bluetongue.ch), and presentations at agricultural fairs and meetings. Clinical sentinel surveillance in sheep was initiated in November 2007 to strengthen surveillance in small ruminants. In contrast to the two other surveillance methods, this method was spatially focused on the Cantons Basel-Landschaft, Basel-Stadt, Solothurn and Aargau, the area where cases of BT had been found previously, but farms from other Cantons were also included. The current epidemic of BTV-8 has spread rapidly over large areas, and within those areas affected high levels of seroprevalence were observed after a short time (Saegerman et al., 2008). But if, for example, only few infected vectors are introduced, the prevalence at the start of an epidemic can be low. Then regional differences in the level of surveillance intensity may bias the observed spatial distribution of the cases. Additionally, regional prevalence estimates, if they are different, provide insight into spatial differences in the infection pressure that can be expected in the future. It is therefore important to analyse any surveillance system and determine regional differences that may occur when estimating spatial prevalence (Berke, 2005).

Cluster analysis in spatial epidemiology is concerned with the spatial distribution of risk and finding areas of increased risk by analysing the distribution of events (often cases) by taking into account spatial heterogeneity in the underlying population at risk, where concentrations of individuals or farms are unevenly distributed across an area (Carpenter, 2001). In this paper, the distribution of clinical suspect data from cattle and sheep may reflect both the underlying distribution of the population at risk and local factors affecting variation. For example if a BTV-8 positive farm is in the area, or if a veterinary practice in that region is more proactive. Most applications of cluster analysis have been confined to the field of epidemiology and health events, although it is suitable for any spatially distributed data. In epidemiology, this technique has, to the author's knowledge, never been used to examine the spatial distribution of surveillance intensity, rather than standard case and population data. But the perceived spatial variability in Switzerland's BT surveillance methods evoke the use of such a technique when looking to determine surveillance intensity. This study aims to provide a descriptive and spatial analysis of the BT (BTV-8) surveillance schemes currently in place for susceptible animals in Switzerland. Based on the results, regional prevalence estimates of BTV-8 infection by the end of the 2007 vector period should be determined.

Materials and Methods

We examined data collected from the bulk milk surveillance scheme between 27th October 2007 and 17th April 2008, clinical suspects reported between 10th July 2007 and 22nd April 2008, and sheep clinical surveillance from 30th November 2007 to 30th April 2008 for BTV-8 on farms throughout Switzerland. Table 1 shows the number of farms and animals recruited for each surveillance

546 Originalarbeiten

method per BT-region, as well as the overall number of farms and animals per BT-region. The population data was derived from the Agricultural database 2006 (AGIS 2006, Federal Office for Agriculture).

Clinical suspects

BT is a notifiable disease in Switzerland and every suspicion of BT must be forwarded to the Cantonal veterinarian who sends a blood sample to the national reference laboratory for BT, the Institute of Virology and Immunoprophylaxis (IVI), Mittelhäusern. Plasma or serum samples from clinical suspects were tested at the IVI for the presence of BT-specific antibodies using a competitive ELISA (VMRD, Veterinary Medical Research and Development Inc., Pullman, WA, USA).

Viral genome detection was performed with a real-time RT-PCR, developed by Hofmann et al. (2008). When the samples were determined to be positive in both tests, the animals were declared positive for BT. If a discrepancy was observed, two additional competitive ELISAs, ID.Screen Bluetongue Competition (ID.VET, Montpellier, France) and Blue Tongue Competitive ELISA Kit (B.D.S.L., Irvine, UK), and two rt RT-PCR tests were performed, with a new blood sample sought.

Bulk milk samples

Samples were taken monthly, for the quality testing of milk by the two quality control laboratories Swisslab, Zollikofen and Qualitas AG, Zug. There the samples were frozen and sent in batches of 20, at least every two weeks, to the IVI. Samples were left at 4° C for at least 24 hours. The samples were tested for the presence of BT-specific antibodies using the indirect ELISA 'ID Screen® Bluetongue Milk Indirect'. Farms with a positive result were replaced by new farms from a list of reserve farms.

Positive samples were tested twice, and if a positive result was obtained a second time, ETDA-blood samples were taken from all cows on the farm. These samples were analysed using the same procedure as clinical suspects except that PCR was only applied if samples were seropositive.

Sheep surveillance

Members of the National Health Service for Small Ruminants (BGK) were requested to participate in a voluntary programme for the regular monthly reporting of BT clinical signs to the FVO. The 28 participating farmers were informed about BT and its surveillance in courses run in November 2007, and started to report their observations in April 2008.

Data management and descriptive analysis

Data management was undertaken in Microsoft Access and descriptive statistical analyses were performed in Microsoft Excel. The Geographical Information System (GIS) package ArcView 9.1 (Environmental Systems Research Institute, Redlands, USA) was used to create the maps and aggregate data on the administrative districts at the county level ('Bezirke').

Cluster analysis

An assessment of spatial clustering of surveillance data for each of the surveillance methods, both independently and with all surveillance types combined, was made with the spatial scan statistic using a Poisson- based model in the SaTScan™ software (Kulldorff and Nagarwalla, 1995). The scanning window was circular, and the radius of the window varied continuously in size from 0–50% of the population at risk. For each location, the alternative hypothesis was that there was an elevated risk of a farm being included in BTV-8 surveillance within the window, as compared to outside. Each surveillance method was considered separately and in combination. 'Cases' comprised of the farms included in each surveillance method while the population at risk included all cattle, sheep and dairy farms within Switzerland.

Global spatial autocorrelation was evaluated on the county level using Moran's I statistic in the Geoda™ 0.9.5-i software (Spatial Analysis Laboratory, University of Illinois, USA). The observed test statistic was compared to a Monte Carlo Randomization distribution (999 simulations) which uses an alogarithm to generate spatially random simulated data sets, as outlined by Anselin (1986), to obtain a Monte Carlo p-value for significance.

Prevalence estimates

Prevalence estimates were calculated using a Binomial predictive model using the Beta function in @Risk (Palisade Corporation, Ithaca, USA). The model was run using a Monte Carlo simulation of 1000 iterations.

Results

Descriptive statistics

Between 29th October 2007 and 8th February 2008, a total of 12 cattle tested positive for BTV-8. Of these 12 cattle, from 3 different farms, 9 of the cases were identified as clinical suspect cases while the other 3 tested positive on separate farms via bulk milk serology. Four cases in the Cantons Basel-Stadt, Basel-Land and Solothurn occurred in a confined area, whereas two cases found by bulk milk serology were distant from this area (Fig. 2).

A total of 207 different cattle farms were tested using the bulk milk surveillance programme and of these, 10 false positive farms were produced, testing positive for bulk milk antibodies but negative for the follow-up tests.
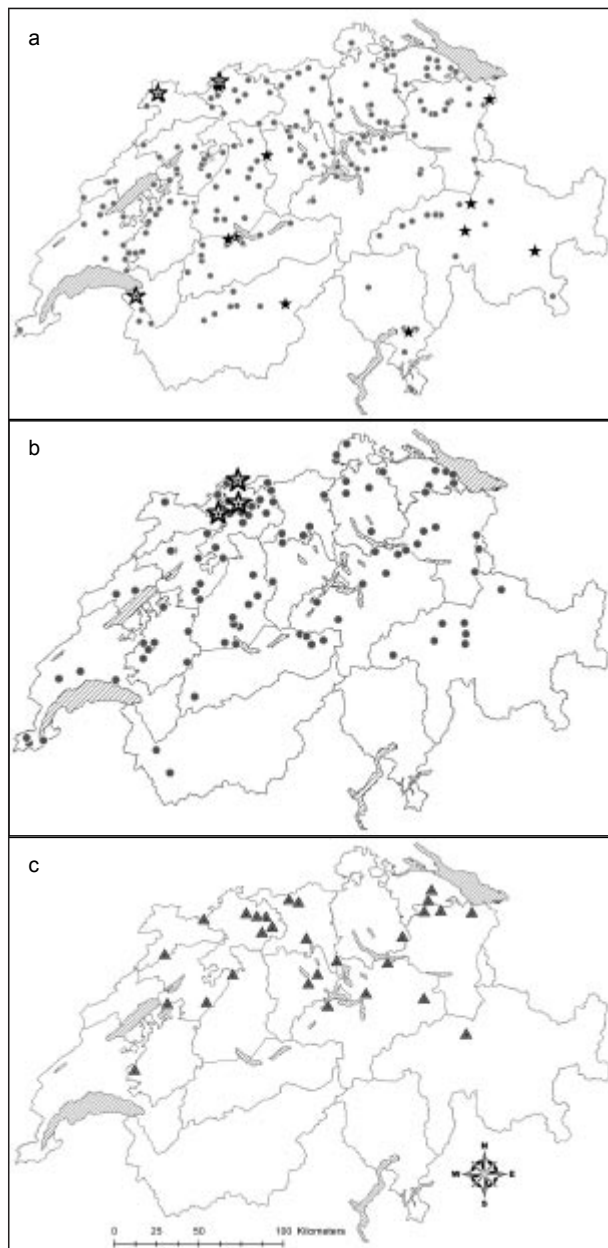
Figure 2: a) Spatial distribution of Bluetongue bulk milk surveillance. b) Spatial distribution of Bluetongue clinical suspect reports. c) Spatial distribution of Bluetongue sheep surveillance farms. Hollow stars: true positive Bluetongue virus 8 farm. Black stars: false positive Bluetongue virus 8 farm (pos. milk; neg. serum). Point: negative farm. Triangle: sheep surveillance farm

Clinical suspects from a total of 122 farms were reported, with 119 of these farms testing negative and 3 testing positive for BTV-8. 92 of these reports were for cattle, 26 for sheep, 2 for goats, and the 2 remaining clinical suspect reports for buffalo. The highest numbers of reports were received from the Cantons of Bern, Basel-Landschaft and Solothurn, with 18%, 13.9% and 11.5% of clinical suspects respectively. The Canton of Jura exhibited the lowest number of reports, with only 0.8% followed by the

Cantons of Valais and Neuchâtel, both with a figure of just 1.6%. Figure 3 shows the temporal distribution of clinical suspect reports with the highest number of clinical suspects between October and November 2007. The locations of the 28 sheep farms involved in the clinical sentinel surveillance exhibited highest numbers in the Cantons of Bern, Solothurn, Basel-Landschaft, Sankt Gallen and Aargau, with 3 farms in each, but no farms were included in the Cantons of Uri, Obwalden, Basel-Stadt, Schaffhausen, Appenzell, Ticino, Vaud, Valais, Neuchâtel or Genève (Fig. 2).
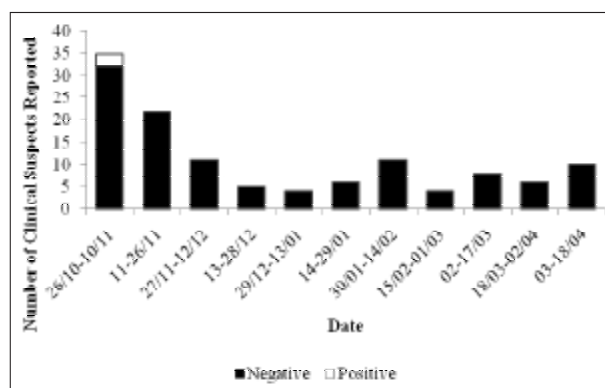

Figure 3: Temporal distribution of clinical suspect reports for Bluetongue between 26th October 2007 and 18th April 2008.

Cluster analysis

Assessment of spatial clustering with the spatial scan statistic identified two statistically significant clusters for all surveillance methods combined. The most likely cluster (radius 22.8 km, P=0.001, Cluster A) incorporated the Cantons of Aargau, Basel-Landschaft, Basel Stadt, Jura and Solothurn (Fig. 1). The smaller secondary cluster (radius 4.9 km, P=0.002, Cluster B) was based in Ticino. The relative risk of a farm being included in the surveillance methods was shown to be 5.85 times higher inside Cluster A, and 28.21 times higher inside Cluster B when compared to outside the clusters. Global spatial autocorrelation using Moran's I statistic was 0.164 (P = 0.001), indicating a significant degree of spatial dependence in the surveillance data. Table 2 shows the results obtained from the other combinations of surveillance methods considered using the Moran's I and the spatial scan statistic.

Prevalence estimates

The prevalence estimate within Cluster A was significantly higher with 9.62% (95% CI= 3.25%-18.85%) compared to the prevalence of 0.98% (95% CI=0.2%-2.22%) outside this cluster (Fig. 4). Four of the BTV-8 positive

Table 2: Results obtained from Moran's I cluster statistic and the SaTScan spatial scan statistic, with respective p-values for each surveillance method analysed, either individually or combined. (significant p-value ≤0.05). sig: significant, nsig: not significant.

Surveillance Method	Species Included	Moran's I Statistic[1]		SaTScan Spatial Scan Statistic[2]			
		Obtained (I)	p-value	Radius (km)	Relative Risk	Surveillance Farms in Cluster	Cantons
Bulk milk	All (Cattle)	0.0195	nsig	4.9/-	45.5/-	7	TI/-
Sheep Surveillance	All (Sheep)	0.1409	sig	14.4/-	18.6/-	7	AG, BL, SO
Clinical Suspect Cases	Cattle Only	0.1269	sig	25.7/*	6.4/-	21	BE, LU, NI, OB, UR, VS
	Sheep Only	0.0975	sig	-	-	-	-
	Goats Only	-0.0100	nsig	-	-	-	-
	Cattle and Sheep	0.1847	sig	18/8.3	14.2/97.3	26/4	AG, BL, BS, SO/ GE
	All (Cattle, Sheep and Goats)	0.2299	sig	18/8.3	15.4/86.3	31/4	AG, BL, BS, SO/ GE
Bulk milk and Sheep Surveillance	All (Cattle and Sheep)	0.0864	sig	4.9/-	42.8/-	7	TI
All Surveillance Types	All (Cattle, Sheep and Goats	0.1639	sig	22.8$/4.9	5.85/28.21	50/7	AG, BL, BS, JU, SO/ TI

[1]Expected (E[I]) Moran's I statistic = –0.0051
[2]Only two most likely significant clusters presented
[3]Includes bulk milk testing, sheep surveillance and clinical suspect cases
[4]5 other significant clusters of smaller radius detected (0.5–2.2km)
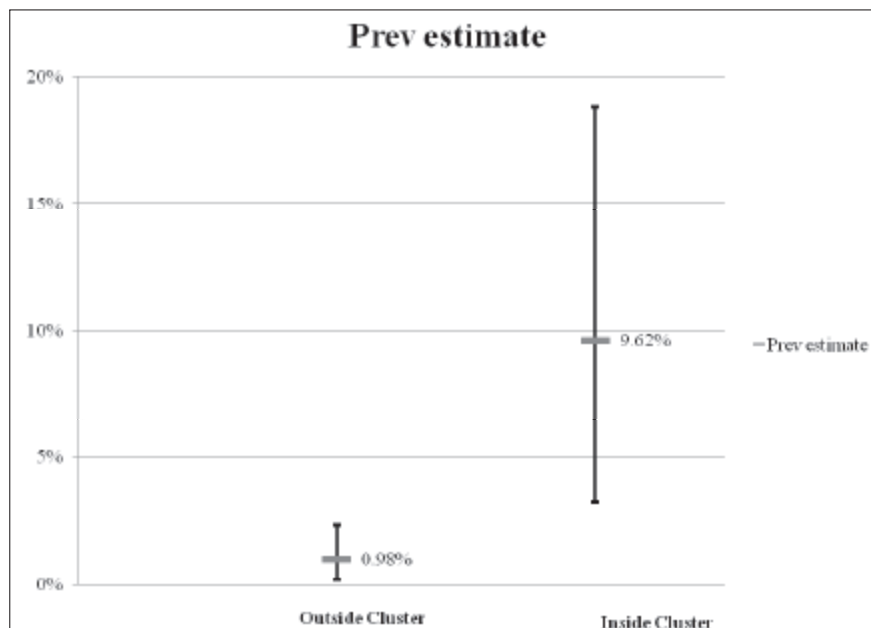[5]Cluster A

Figure 4: Prevalence estimates with the 95% confidence intervals for Bluetongue virus 8 in Switzerland both within and outside of the most likely cluster (cluster A) identified from SatScan cluster analysis on all surveillance methods combined.

farms in Switzerland were included in cluster A. From this figure the estimate for the number of infected farms within the cluster is 136 (95% CI= 46 – 267) out of a total of 1,415 farms, and 494 outside the cluster (95% CI= 101 – 1,175) from a total of 50,365 farms.

Discussion

Descriptive analyses

Surveillance for BT disease in Switzerland between 27th October 2007 and 17th April 2008 confirmed the presence of BTV-8 positive cattle in the Cantons of Basel-Stadt, Solothurn and Basel-Landschaft via clinical suspect reports, as well as Jura, Valais and, once again, Basel-Landschaft, via bulk milk testing. We have excluded one case in goats from the Canton Solothurn from this work, as this case was detected in export testing and therefore not in the surveillance methods considered in this work. While the 3 clinical cases occurred in a confined area, the 3 cases found with bulk milk serology were widely distributed. The producer states a sensitivity of the test of 100% in pooled samples for one positive from up to 50 cows. In our data 14 false positive findings occurred using this method, as shown in Figure 2a. In these cases, serological blood testing was carried out on the whole herd involved. Despite clinical surveillance in sheep on 28 farms throughout Switzerland, as well as 26 farms presenting with clinical suspect sheep, no sheep have currently been confirmed as BTV-8 positive in Switzerland.

Switzerland detected its first BT case in late October 2007 through clinical surveillance and in the last six months the reporting of clinical suspect cases has increased dramatically as compared to previous years, where roughly 10 reports were received per year. The high number of clinical suspects between October and November 2007 is consistent with the release of the BT documentary in August by the FVO leading to an increase in disease awareness. The 11 false positive bulk milk results identified up until 14th November may have also lead to increased awareness among local practitioners. The decreasing level of reports towards the end of 2007 corresponds with the start of the vector free-season in December 2007.

Although the largest number of clinical suspect reports were received from the Canton of Bern, the Cantonal cattle and sheep population present would already dictate the likelihood of a higher number of reports from this Canton. This is especially true when compared to Cantons Jura and Neuchatel who had the lowest and second lowest numbers of reports respectively, and who, even when merged together to form one BT-region, still contain the lowest population of sheep farms of all the BT-regions (Tab. 1). However, such comparison is better done between BT-regions, as they were defined by taking into account the area and population at risk. Then it

is actually the newly combined Cantons of Basel-Landschaft, Basel-Stadt and Solothurn that exhibit the highest number of reports (Tab. 1). But the comparison of clinical surveillance data between Cantons is advantageous over the comparison between BT-regions, as the CVS are responsible for the performance of clinical surveillance.

Cluster analyses

We expected clustering in areas where increased surveillance activities were either purposefully initiated, in the case of clinical sentinel surveillance in sheep and a proactive CVS or expected, due to the presence of BT cases within that region and aimed at testing this statistically. The spatial scan methodology is appropriate for the detection of real clusters in the surveillance data as it adjusts for the underlying spatial inhomogeneity of a background population. While for this reason Kulldorff's scan statistic (Kulldorff, 1997) has become the most widely used test for clustering in recent years, the circular scanning window has difficulty in detecting noncircular and long, narrow clusters in data which may be seen on country borders. As it has been suggested that two different methods should be combined in any cluster analysis in order to reduce the likelihood of detecting false positive clustering (Carpenter, 2001), we applied Moran's I a global cluster test on the same data to confirm the presence of clustering.

Primary cluster

Cluster A incorporates 4 out of the 6 positive. Spatial scan statistic undertaken on the sheep surveillance data only also confirmed a cluster in this area (Tab. 2). This confirms the increased intensity of surveillance in the area and also corresponds with the original aim of the sheep surveillance which was to focus spatially on the Cantons Basel-Landschaft, Basel-Stadt, Solothurn and Aargau, as this was the area where cases of BT had been found previously. This resulted in, as we have shown, the area of higher surveillance corresponding with the area of higher BT prevalence. Spatial scan statistic on all clinical suspect reports also produced a cluster within this area, as confirmed by the Moran's I statistic for all clinical suspects (Tab. 2). Thus the clustering of clinical suspect data, as expected due to an increased disease awareness in the area, could be shown to be statistically significant.

The Moran's I statistic for all surveillance methods combined indicated that geographic variation in the number of farms included in the surveillance did not follow the geographic variation in the total number of farms in Switzerland and there was therefore clustering of the surveillance within a region.

Secondary clusters

Cluster B was located in the Canton of Ticino. Incorporating solely bulk milk testing data in the spatial scan statis-

tic also resulted in the same cluster, highlighting the role that the spatial distribution of the bulk milk surveillance scheme played in the formation of this surveillance cluster. 7 of the 13 bulk milk farms located in Ticino (Tab 1) are included in this cluster (Fig 1). The selection of farms was done by the CVS, as all randomly selected farms suggested by the FVO were replaced with farms that were believed to be at higher risk for BT. But interestingly, the Moran's I statistic for bulk milk testing does not support the presence of clusters in the bulk milk surveillance data. This result indicates that the cluster detected by the spatial scan statistic is an artefact due to the high sensitivity of this method (Kulldorff et al., 2003).

When only considering clinical suspect reports obtained from cattle farms, six significant clusters were found, the largest of which can be seen in Table 2. All clusters except for one were very small and comprised 2 to 7 surveillance farms. Interestingly, the Moran's I test was also significant for this dataset. The most likely explanation for this observation is that spatial autocorrelation is present in the dataset, but the clusters identified are again an artefact of the spatial scan statistic. The most likely explanation for this phenomenon is a local effect of single veterinarians as well as a relationship between neighbouring farmers reporting clinical suspects.

A significantly higher BTV-8 prevalence was determined inside Cluster A compared to outside, once again supporting the premise that the distribution of clinical suspect data, as well as all surveillance methods combined, is more intense in regions of higher risk for BTV-8 positive farms. Performing a cluster analysis of the surveillance data followed by a regional prevalence estimation means it was only data driven and therefore favourable compared to the interpretation of data aggregated on administrative regions. For clinical suspects, the assumption of 100% sensitivity on the farm level, if only one or few animals are blood tested, is arguable for sheep farms where animals usually show clinical symptoms when the farm is infected, but must be used with caution in the interpretation of the data from cattle farms. However, it was not possible to get quantitative data to improve the approach.

We made the assumption that infections that occurred in autumn 2007 were detectable in spring 2008 by all surveillance methods. This assumption stands true for bulk milk testing, but it would depend on new infections occurring on clinical surveillance farms, as the presence of clinical symptoms is limited to a few weeks after infection (Backx et al., 2007). But it should be considered that most of the clinical suspects were reported in autumn 2007, and therefore at a time point of the epidemic when infections occurred and clinical symptoms were likely to be present.

The results presented show a high level of surveillance intensity for BT all over Switzerland in 2007. In the area where cases were detected early in 2007, the surveillance was significantly higher than in the rest of Switzerland. Additionally, the prevalence estimates are higher for that area. In contrast with the findings in the UK, where the prevalence of infected herds within 10 km of the first 4 cases of BT identified was determined to be 58.8% (DEFRA, 2007), we were able to show that the estimated prevalence of infected farms was much lower in Switzerland, even in the cluster region. This suggests a limited incursion of infectivity either through vectors or hosts or a less effective transmission prior to case detection in Switzerland compared to the situation in UK. On the national scale, such spatial variation in surveillance data needs to be considered if the epidemic is interpreted. Based on the useful utilisation of data from clinical suspects, this method will be of high value within the future BT surveillance in Switzerland, especially as all susceptible species will be vaccinated against BTV-8 from autumn 2008 onwards.

Acknowledgment

Répartition territoriale de la surveillance et des cas de maladie de la langue bleue (fièvre catarrhale ovine) en Suisse

De mi 2007 à mi 2008, la surveillance de la fièvre catarrhale en Suisse a été réalisée au moyen d'examens de prélèvements de lait de mélange dans 200 troupeaux et d'une observation clinique renforcée. Les troupeaux bovins ont été choisis de façon ciblée dans des régions où la présence des vecteurs était fortement vraisemblable. Au moyen de « Spatial Scan Statistic » et de « Moran's 1 Statistic », les résultats de la surveillance

Ripartizione geografica della sorveglianza e dei casi di malattia della lingua blu in Svizzera

Da metà 2007 fino a metà 2008 la sorveglianza della malattia della lingua blu in Svizzera si compone di analisi mensili combinate formate da una raccolta di campioni di latte provenienti da 200 mandrie di bovini e da una sorveglianza clinica rinforzata. Le aziende di bovini sono state scelte in zone con una maggiore probabilità di ritrovare il vettore. Utilizzando la ,Spatial Scan Statistic" e la ,Moran's l Statistic" sono stati esaminati i dati rilevati dalla sorveglianza in relazione

ont été examinés quand à des accumulations locales (cluster). Les résultats montrent une intensité de surveillance élevée en 2007 dans une région qui comprend les cantons d'Argovie, Bâle-Campagne, Bâle-Ville et Soleure, à savoir la région où des cas ont été diagnostiqués en 2007. L'intensité de la surveillance clinique y était significativement plus haute que dans le reste de la Suisse. Dans le cadre de ce programme, 6 cas ont été découverts. Les valeurs estimées de prévalence étaient de 9,62 % (95% CI = 0.2 % - 2.22%) dans la région avec une haute intensité de surveillance contre 0.98% (95% CI = 0.2% - 2,22 %) hors de cette zone soit significativement plus élevée. On doit donc tenir compte des particularités territoriales lors d'examens relatifs à l'apparition d'une épizootie. De même, la répartition géographique des valeurs estimées de prévalence en Suisse devraient être prise en compte pour la surveillance future de la fièvre catarrhale.

alla frequenza geografica (Cluster). Dai risultati si rileva per il 2007 una maggiore intensità della sorveglianza in Svizzera. Nella regione che comprende i cantoni di Argovia, Basilea Campania, Basíiea Città e Soletta e nella zona che nel 2007 ha avuto casi di malattia della lingua blu, l'intensità della sorveglianza è stata maggiore che nel resto della Svizzera. Nel quadro dei programma di sorveglianza sono stai scoperti 6 casi. I valori stimati di prevalenza erano maggiori all'interno della zona con un alto grado di sorveglianza, 9.62% (95% Ci=3.25%18.85%), mentre nelle altre zone erano dello 0.98% (95% Cl=0.2%-2.22%). Quindi è importante che durante le analisi sulla comparsa di focolai epizooteci le differenze geografiche vengano considerate nella messa ìn atto dell'intensità di sorveglianza. Nelle sorveglianze in futuro della malattia della lingua blu si dovrebbe considerare in Svizzera la ripartizione geografica dei valori di prevalenza stimati.

References

Anonymous: Commission Regulation 1266/2007/EC of 26 October 2007 on implementing rules for Council Directive 2000/75/EC as regards the control, monitoring, surveillance and restrictions on movements of certain animals of susceptible species in relation to bluetongue, 2007a.

Anonymous: Initial epidemiological report on the outbreak of Bluetongue in East Anglia and south east England from investigations completed to 19th October 2007. Department for Environment Food and Rural Affairs (DEFRA). [Available online at http://www.defra.gov.uk/animalh/diseases/notifiable/bluetongue/pdf/epidemiology-report301007.pdf], 2007b.

Anonymous: Animal Diseases Data: Bluetongue. World Organisation for Animal Health (OIE). [Available online at http://www.oie.int/eng/maladies/fisches/a_A090.htm], 2008a.

Anonymous: World Animal Health Information Database (WAHID). World Organisation for Animal Health (OIE). [Available online at http://www.oie.int/wahid-prod/public.php?page=home], 2008b.

Anselin L.: MicroQAP: a microcomputer implementation of generalized measures of spatial association. In Working paper. University of California, Santa Barbara, Department of Geography. 1986.

Backx A.: Clinical signs in ruminants: outbreak and experimental BTV8 infection & longitudinal field study. Central Institute for Animal Disease Control (CIDC-Lelystad), Wageningen. [Available online at http://www.cvi.wur.nl/NR/rdonlyres/681038D6-7127-4CC0-A4A6-18F2D748CD6F/53887/08Clinicalsignsinruminants.pdf], 2008.

Backx A., Heutink C. G., van Rooij E. M., van Rijn P. A.: Clinical signs of bluetongue virus serotype 8 infection in sheep and goats. Vet. Rec. 2007, 161: 591–592.

Berke O.: Exploratory spatial relative risk mapping. Prev. Vet. Med. 2005, 71: 173–182.

Bonneau K. R., DeMaula C. D., Mullens B. A., MacLachlan N. J.: Duration of viraemia infectious to Culicoides sonorensis in bluetongue virus-infected cattle and sheep. Vet. Microbiol. 2002, 88: 115–125.

Cagienard A., Dall'Acqua F., Thür B., Mellor P. S., Denison E., Griot C., Stärk K. D. C.: Bluetongue surveillance in Switzerland in 2003. Veterinaria Italiana 2004, 40: 133–136.

Cagienard A., Thur B., Griot C., Hamblin C., Stärk K. D.: No evidence of bluetongue virus in Switzerland. Vet. Microbiol. 2006, 116: 13–20.

Carpenter T. E.: Methods to investigate spatial and temporal clustering in veterinary epidemiology. Prev. Vet. Med. 2001, 48: 303–320.

Hofmann M., Griot C., Chaignat V., Perler L., Thür B.: Blauzungenkrankheit erreicht die Schweiz. Schweiz. Arch. Tierheilk. 2008, 150: 49–56.

Kulldorff M.: A spatial scan statistic. Commun. Statist. Theory and Methods. 1997, 1: 355–358.

Kulldorff M., Nagarwalla N.: Spatial disease clusters: detection and inference. Stat. Med. 1995, 14: 799–810.

Kulldorff M., Tango T., Park P.: Power comparisons for disease

clustering tests. Computational Statistics and Data Analysis 2003, 42: 665–684.

MacLachlan N. J.: The pathogenesis and immunology of bluetongue virus infection of ruminants. Comp. Immunol. Microbiol. Infect. Dis. 1994, 17: 197–206.

Mellor P. S., Boorman J., Baylis M.: Culicoides biting midges: their role as arbovirus vectors. Annu. Rev. Entomol. 2000, 45: 307–340.

Mellor P. S., Carpenter S., Harrup L., Baylis M., Mertens P. P.: Bluetongue in Europe and the Mediterranean Basin: History of occurrence prior to 2006. Prev. Vet. Med. 2008, Jul 9. [Epub ahead of print]

Mertens P. P. C., Attoui H., Bamford D. H.: The RNAs and proteins of dsRNA viruses. Institute for Animal Health, Pirbright, UK. [Available online at http://www.iah.bbsrc.ac.uk/dsRNA_virus_proteins/Orbivirus.htm], 2008.

Racloz V., Straver R., Kuhn M., Thur B., Vanzetti T., Stärk K. D., Griot C., Cagienard A.: Establishment of an early warning system against bluetongue virus in Switzerland. Schweiz. Arch. Tierheilk. 2006, 148: 593–598.

Racloz V., Griot C., Stärk K. D. C.: Sentinal surveillance systems with special focus on vector-borne diseases. Animal Health Research Reviews 2007, 7: 71–79.

Saegerman C., Berkvens D., Mellor P. S.: Bluetongue epidemiology in the European Union. Emerg. Infect. Dis. 2008, 14: 539–544.

Schwermer H., Chaignat V., Thür B., Hadorn D., Schärrer S., Schaffner F., Breidenbach E.: The monitoring programme of bluetongue disease in Switzerland. Schweiz. Arch. Tierheilk. 2008, 150: 129–132.

Correspondence

Heinzpeter Schwermer
Bundesamt für Veterinärwesen
Schwarzenburgstrasse 155
CH 3003 Bern- Liebefeld
E-mail: heinzpeter.schwermer@bvet.admin.ch